Prevalence of Self-Rated Visual Impairment Among Adults With Diabetes

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ABSTRACT

Objectives. This study estimated the prevalence of self-rated visual impairment among US adults with diabetes and identified correlates of such impairment.

Methods. Self-reported data from the 1995 Behavioral Risk Factor Surveillance System survey of adults 18 years and older with diabetes were analyzed. Correlates of visual impairment were examined by multiple logistic regression analysis.

Results. The prevalence of self-rated visual impairment was 24.8% (95% confidence interval [CI] = 22.3%, 27.3%). Among insulin users, multivariable-adjusted odds ratios were 4.9 (95% CI = 2.6, 9.2) for those who had not completed high school and 1.8 (95% CI = 1.0, 2.8) for those who had completed high school compared with those with higher levels of education. Comparable estimates of odds ratios for nonusers of insulin were 2.2 (95% CI = 1.4, 3.4) and 1.3 (95% CI = 0.9, 2.0), respectively. Among nonusers, the adjusted odds for minority adults were 2.4 (95% CI = 1.0, 3.7) times the odds for non-Hispanic Whites.

Conclusions. By these data, 1.6 million US adults with diabetes reported having some degree of visual impairment. Future research on the specific causes of visual impairment may help in estimating the avoidable public health burden. (*Am J Public Health.* 1999;89:1200–1205)

Ocular complications from diabetes, ranging from minimal loss of visual acuity to legal blindness, represent a major public health problem.[1] The individual and societal burdens of legal blindness due to diabetes have been studied.[1–4] Legal blindness accounts for 55% of visual impairment among persons with younger-onset diabetes (diagnosed before 30 years of age) and 28% of visual impairment among persons with older-onset diabetes (diagnosed at 30 years and older).[2] Efforts to reduce the burden of blindness could yield net national savings exceeding $500 million.[5]

Currently available population-based estimates of levels of visual impairment and blindness among people with diabetes are based on either data from selected populations[2] or data that have not been evaluated for accuracy and completeness of reporting.[4] Furthermore, the data from these sources are based on standard clinical assessment of an individual's ability to discriminate letters fixated by the central retina (Snellen acuity). These data may underestimate the total burden of visual disability among people with diabetes because Snellen acuity decrements capture only a portion of the disability engendered in vision, visual functioning, and overall functional health status.[5–8] Measurement of self-rated visual functioning may provide a more comprehensive assessment of the extent of visual impairment among persons with diabetes.

This report describes the prevalence of self-rated visual impairment and the factors associated with such impairment among 3391 adults with diabetes who participated in the 1995 Behavioral Risk Factor Surveillance System (BRFSS) survey.

Methods

The BRFSS is a continuous, random-digit-dialed telephone survey of state population–based samples of the civilian noninstitutionalized adult population 18 years and older; it is conducted in all 50 states and the District of Columbia.[9] To assess best-corrected visual acuity, the BRFSS questionnaire includes an optional diabetes module incorporating a 3-item questionnaire on vision-dependent activities (Figure 1) that was developed in the Beaver Dam Health Outcomes Study (BDHOS) to measure subjective assessment of visual functioning.[10,11] Data from the 39 states that used the BRFSS diabetes module in 1995 were aggregated for this analysis. When compared with measured visual acuity in the best-corrected eye, the BDHOS questionnaire has been shown to have good to excellent validity for identifying poor vision among diabetic adults of various ethnic origins and socioeconomic status.[11,12]

Responses to the BDHOS questions were coded numerically on a 5-point scale, with declining score indicating worsening rating of visual functions. To estimate visual acuity, we substituted the scores for each question into the BDHOS regression equation, 1.8 + 3.0 <street question> + 4.5 <news question> + 2.6 <TV question>. Visual acuity was measured as the number of letters read

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on the LogMar chart. Persons with estimated visual acuity of fewer than 36 letters were classified as having visual impairment (36–40 letters on the LogMar chart is similar to 20/40 in Snellen acuity).

Persons with diabetes were identified by a yes response to the question, "Have you ever been told by a doctor that you have diabetes?" Women who were told only during pregnancy that they had diabetes (i.e., were told they had diabetes) were classified as not having diabetes. Duration and type of diabetes were derived from age at interview, age at diagnosis, and insulin use. Persons with diabetes diagnosed before 30 years of age who were using insulin were classified as having type 1 diabetes; those diagnosed at 30 years and older or those diagnosed before 30 years of age who were not using insulin were classified as having type 2 diabetes.[13] Persons with type 2 diabetes were then stratified according to insulin use. Three types of variables, chosen because of their known association with visual impairment,[14–16] were selected as possible correlates of self-reported impaired vision: (1) sociodemographic (age, sex, race/ethnicity, employment, and education), (2) clinical status (duration of diabetes, smoking, and hypertension status), and (3) access to and use of health care services (health care insurance coverage, at least 1 visit for diabetes care in the previous year, and receipt of a dilated eye examination in the previous year).

Prevalence of visual impairment was first estimated for the total sample and then according to type of diabetes. To compare persons with type 1 diabetes and those with type 2 diabetes, estimates were adjusted to the age distribution of the total population studied.[17] Multiple logistic regression models were fitted with type of diabetes as a categorical variable and age as a continuous variable. The partial coefficient for each type of diabetes and the mean age of the total study population were then used to compute the expected probability of visual impairment in the groups with different types of diabetes. In the first analyses, age-adjusted estimates for persons with type 1 diabetes and for those with type 2 diabetes who used insulin were each compared with the age-adjusted estimate for persons with type 2 diabetes who did not use insulin. The analyses were then repeated for comparisons among the insulin users (type 1 vs type 2).

Because the risk of visual impairment is greater for persons who use insulin than for those who do not,[18] the effects of the 3 types of variables—sociodemographic, clinical, and access to and use of health care services—were examined separately for users and nonusers of insulin. In univariate analyses, associations between visual impairment and each of these variables were assessed using χ^2 tests. To identify characteristics associated with visual impairment, we fitted a multiple logistic regression model with all selected variables to estimate the odds ratios with 95% confidence intervals for the main effects of each variable, controlling for the effects of all other variables. Because of the strong correlation between age and duration of diabetes, we kept only age in the model. To evaluate the importance of the covariates and the robustness of the models, we entered each variable sequentially to observe the impact on the associations once variables were in the model. The significance of the main effect was tested with the Wald F test,[19] which simultaneously tests for equality among levels of an independent variable. All analyses were done with SAS (SAS Institute, Inc, Cary, NC), and SUDAAN (Research Triangle Institute, Research Triangle Park, NC) was used to calculate standard errors because of the complex survey design of the BRFSS.[19]

I would now like to ask you 3 questions about how well you see with your glasses or contacts on if you use them.

1. How much of the time does your vision limit you in recognizing people or objects across the street? (Street question.)
2. How much of the time does your vision limit you in reading print in newspapers, magazines, recipes, menus, or numbers on the telephone? (News question.)
3. How much of the time does your vision limit you in watching television? (TV question.)

Responses were coded as either 1 (all the time), 2 (most of the time), 3 (some of the time), 4 (a little of the time), or 5 (none of the time).

FIGURE 1—Questions on visual functioning from the diabetes module: Behavioral Risk Factor Surveillance System, 1995.

TABLE 1—Characteristics of Persons With Diabetes Aged 18 Years and Older in States That Used the Diabetes Module: Behavioral Risk Factor Surveillance System, 1995

Characteristic	Sample Size (n = 3391)	Weighted Estimate (%)	±1.96 × Standard Error
Sociodemographic			
+65 y	1553	38.8	3.0
Female	2019	55.5	3.2
Non-Hispanic White	2677	73.9	3.7
Employed	1127	38.1	3.0
< High school education	993	28.7	2.7
Clinical status			
Type 2 diabetes	3045	91.7	3.6
Insulin use	1343	38.6	3.6
Duration of diabetes ≥ 10 y	1608	47.0	3.4
Current smoker	583	17.9	3.3
High blood pressure	1702	49.3	3.3
Health care access			
Health plan	3105	88.9	3.3
Dilated eye examination in previous year	2157	62.8	3.4
At least 1 visit for diabetes in previous year	2879	86.2	1.9

Results

Among the 39 states that included the diabetes module in the 1995 BRFSS survey, the median response rate was 80.1% (range = 60.5%–95.0%).[20] Of the 85 447 respondents 18 years and older who were interviewed, 3391 (4.0%) reported that they had been told by a doctor that they had diabetes.

The mean age of persons with diabetes was 58.2 years; 55.5% were female, and 73.9% were non-Hispanic White (Table 1). Overall, 28.7% had not finished high school, 38.1% were currently employed, 42.1% were retired, and 14.8% were unable to work. Most (91.7%) had type 2 diabetes, almost two fifths (38.6%) were using insulin, and nearly half (47%) reported having had diabetes for at least 10 years. Most (88.9%) reported that they had health insurance coverage, and 62.8% had received a dilated-eye examination in the previous year.

The overall prevalence of visual impairment was 24.8% (95% confidence interval

[CI] = 22.3%, 27.3%). The prevalence increased significantly with age, from 18.6% among persons aged 18 to 44 years to 24.7% among persons aged 45 to 64 years to 28.0% among those aged 65 and over ($P<.04$, $\chi^2_2 = 6.4$), and it was significantly higher among females than males (27.4% vs 21.6%; $P<.02$, $\chi^2_1 = 5.6$). The crude prevalence of impaired vision was similar among persons with different types of diabetes: 25.2% (95% CI = 16.6%, 33.8%) among persons with type 1 diabetes, 29.2% (95% CI = 23.6%, 34.8%) among persons with type 2 diabetes who were using insulin, and 22.7% (95% CI = 20.0%, 25.4%) among those with type 2 diabetes who were not using insulin ($P = .1$, $\chi^2_1 = 4.5$). After adjustment for age, the odds of having impaired vision were 70% higher for persons with type 1 diabetes (odds ratio [OR] = 1.7; 95% CI = 1.0, 2.9; $P = .02$) and 40% higher for those with type 2 diabetes who used insulin (OR = 1.4; 95% CI = 1.03, 1.9; $P = .02$) compared with nonusers. Among insulin users, the age-adjusted odds did not differ by type of diabetes.

Among males, the prevalence differed by type of diabetes even after adjustment for age. The age-adjusted odds ratios among males with type 1 diabetes and among males with type 2 diabetes who used insulin compared with type 2 nonusers of insulin were 2.3 (95% CI = 1, 5.4) and 1.6 (95% CI = 1.1, 2.5), respectively. Among females, the variation by type of diabetes was not significantly different even after adjustment for age. The odds of having visual impairment were 30% higher for females than for males (OR = 1.3; 95% CI = 1.01, 1.7) after adjustment for age and type of diabetes.

Among insulin users, visual impairment was significantly associated only with employment ($P<.05$, $\chi^2_3 = 9.7$) and level of education ($P<.001$, $\chi^2_2 = 29.4$) (Table 2). Among nonusers of insulin, the percentage of persons who reported visual impairment was significantly higher among females than among males ($P<.01$, $\chi^2_1 = 8.7$), among persons of other ethnic origin than among non-Hispanic Whites ($P<.001$, $\chi^2_1 = 18.6$) and among those who had diabetes for 10 years or more than among those who had diabetes fewer than 10 years ($P<.01$, $\chi^2_1 = 7.6$). The percentage of persons with impaired vision also decreased significantly with increasing level of education ($P<.01$, $\chi^2_2 = 30.9$). Employment status was significantly associated with visual impairment; retired and unemployed persons were more likely to have visual impairment ($P<.01$, $\chi^2_3 = 12.9$). Among the variables not associated with visual impairment in either group were age, smoking, health insurance coverage, visits for diabetes care, and receipt of a dilated eye examination in the previous year.

TABLE 2—Crude Prevalence (%) of Visual Impairment Among Diabetic Users and Nonusers of Insulin, by Independent Variables: Behavioral Risk Factor Surveillance System, 1995

Variable	Insulin Users (n = 1343) %	Insulin Users (n = 1343) ±1.96 SE	Nonusers of Insulin (n = 2045) %	Nonusers of Insulin (n = 2045) ±1.96 SE
Sociodemographic				
Age, y				
18–44	20.2	±10.9	17.1	±5.7
45–64	27.3	±7.0	23.1	±4.5
≥ 65	34.9	±6.5	24.4	±4.3
Sex				
Male	27.4	±6.3	18.3	±3.7
Female	28.8	±7.0	26.5	±3.9
Race				
Non-Hispanic White	28.5	±4.5	19.0	±2.7
Other	27.0	±11.5	37.0	±7.4
Employment				
Employed	21.6	±7.3	17.0	±3.9
Unemployed	12.9	±9.6	34.4	±14.5
Retired	31.9	±6.1	22.0	±4.3
Unable to work	35.3	±19.0	34.5	±10.6
Education				
< High school	49.4	±8.0	35.0	±6.1
High school	26.0	±7.0	20.6	±4.3
> High school	17.2	±7.2	14.0	±3.7
Clinical status				
Duration of diabetes				
< 10 y	26.0	±6.7	19.5	±3.3
± 10 y	29.4	±6.7	28.0	±4.9
High blood pressure				
Yes	30.7	±6.5	26.5	±4.1
No	25.8	±7.0	19.0	±3.5
Smoking status				
Current smoker	24.1	±13.5	22.8	±6.7
Ex-smoker	29.0	±6.9	22.7	±4.7
Nonsmoker	29.2	±6.9	22.6	±3.9
Health care access				
Health plan				
Yes	29.0	±4.5	22.7	±2.9
No	22.7	±19.6	22.4	±8.6
Dilated eye examination in previous year				
Yes	27.4	±4.9	24.2	±4.3
No	30.3	±11.0	21.0	±4.3
At least 1 visit for diabetes in previous year				
Yes	27.8	±4.9	23.0	±3.1
No	33.0	±21.5	18.9	±5.8
Total	28.3	±4.9	22.7	±2.7

Table 3 shows the odds ratios for the association of each covariate with visual impairment among users and nonusers of insulin, adjusted for all other covariates listed. Among insulin users, education was the only variable independently associated with visual impairment ($P<.001$, $\chi^2_2 = 16.8$); the adjusted odds of having visual impairment were almost 5 times higher for those who had not completed high school (OR = 4.9; 95% CI = 2.6, 9.2), and almost 2 times higher for those who had only completed high school (OR = 1.8; 95% CI = 1.0, 2.8), than for insulin users with higher levels of education.

Among nonusers of insulin, education was also significantly associated with impaired vision ($P<.05$, $\chi^2_2 = 4.9$), but the relationship was not as strong as that noted for insulin users. The adjusted odds were 200% higher for those who had not completed high school (OR = 2.2; 95% CI = 1.4, 3.4), and 30% higher for those who had only completed high school (OR = 1.3; 95% CI = 0.9, 2.0), than for those with higher levels of education. Finally, among nonusers of insulin, persons of other racial/ethnic backgrounds had twice the odds of having visual impairment (OR = 2.4; 95% CI = 1.0, 3.7) as non-Hispanic Whites. Figure 2 shows the multivariable-adjusted prevalence of visual impairment among users and nonusers of insulin by race and level of education. In this analysis, sex and employment were no longer significantly associated with visual impairment in either group.

TABLE 3—Adjusted Odds Ratios[a] for Visual Impairment Among Users and Nonusers of Insulin, by Independent Variables: Behavioral Risk Factor Surveillance System, 1995

	Insulin Users (n = 1343)		Nonusers of Insulin (n = 2045)	
Variable	OR	95% CI	OR	95% CI
Sociodemographic				
Age, y	1.01	1.0, 1.03	1.02	1.0, 1.04
Sex				
Male	1.0		1.0	
Female	0.9	0.6, 1.4	1.2	0.8, 1.8
Race/ethnicity				
Non-Hispanic White	1.0		1.0	
Other	0.6	0.3, 1.0	2.4	1.0, 3.7
Employment				
Employed	1.0		1.0	
Unemployed	0.8	0.4, 1.8	1.4	0.8, 2.3
Retired	0.9	0.5, 1.7	0.7	0.5, 1.2
Unable to work	2.0	1.0, 4.3	1.5	0.8, 1.7
Education				
> High school	1.0		1.0	
High school	1.8	1.0, 2.8	1.3	0.9, 2.0
< High school	4.9	2.6, 9.2	2.2	1.4, 3.4
Clinical status				
High blood pressure				
No	1.0		1.0	
Yes	1.1	0.7, 1.7	1.3	1.0, 2.1
Smoking status				
Nonsmoker	1.0		1.0	
Current smoker	0.9	0.4, 1.7	1.1	0.6, 1.8
Ex-smoker	0.9	0.6, 1.5	1.1	0.7, 1.6
Health care access				
Health plan				
Yes	1.0		1.0	
No	1.3	0.5, 3.9	0.9	0.5, 1.7
Dilated eye examination in previous year				
Yes	1.0		1.0	
No	1.2	0.7, 2.0	0.8	0.6, 1.2
At least 1 visit for diabetes in previous year				
Yes	1.0		1.0	
No	1.6	0.6, 4.1	1.1	0.7, 1.6

Note. OR = odds ratio; CI = confidence interval.
[a]Odds ratios are controlled for all other variables in the model.

Discussion

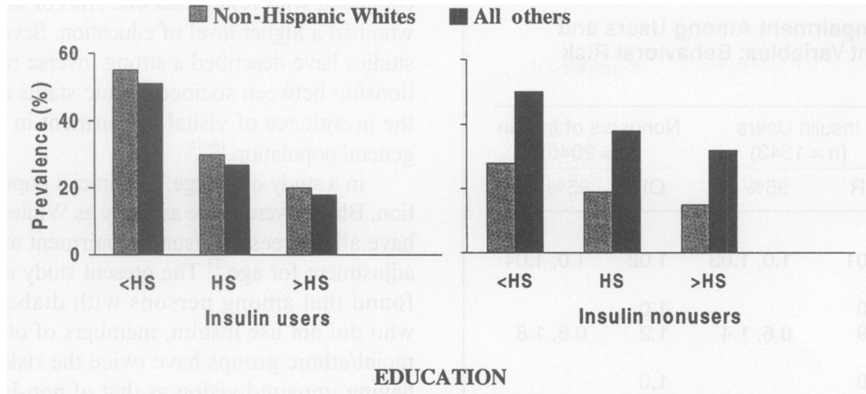
Findings from the 1995 BRFSS survey suggest that 1 in 4 adults with diabetes has self-rated visual impairment, an estimate that is approximately twice as high as previously reported.[2,4] Although a comparison of studies is limited by differences in methodology, the prevalence of visual impairment based on best-corrected distance visual acuity in the Wisconsin Epidemiology Study of Diabetic Retinopathy (WESDR) cohort was 10.4% among subjects with younger-onset diabetes and 13.3% among those with older-onset diabetes[2]; in the 1989 National Health Interview Survey,[4] the prevalence among adults with diabetes was 13.8%. In the WESDR study, however, refractive error and best-corrected distance visual acuity were measured at the time of baseline examination, and the estimate is therefore lower than in the present study because it represents only visual impairment due to causes other than refractive errors. The question used in the National Health Interview Survey has been shown to have low validity for detecting visual impairment among all demographic groups when compared with clinical measurement of visual acuity.[2,21] The prevalence of self-reported visual impairment among BRFSS participants 65 years and older (28%) was identical to that reported from a population-based study in England of persons with known type 2 diabetes who were 60 years and older.[22]

In this study, level of education and race/ethnicity emerged as the most important factors related to self-reported visual impairment. Among persons with diabetes who had not completed high school, almost half of all insulin users and more than one third of nonusers reported having impaired vision, compared with fewer than one fifth of those who had a higher level of education. Several studies have described a strong inverse relationship between socioeconomic status and the prevalence of visual impairment in the general population.[14–16]

In a study of a large, multiracial population, Blacks were twice as likely as Whites to have all degrees of visual impairment after adjustment for age.[23] The present study also found that among persons with diabetes who did not use insulin, members of other racial/ethnic groups have twice the risk of having impaired vision as that of non-Hispanic Whites. One plausible reason for the racial/ethnic difference is that people in minority groups are less likely than Whites to seek medical care. Although persons with diabetes use ambulatory care services at 3 times the rate of the general population, Blacks with diabetes are less likely than their White counterparts to use these services.[24] The 1990 National Ambulatory Care Survey found that even among adults of working age in the general population, Blacks used ambulatory eye care services significantly less often than did Whites and that all minority groups were significantly more likely to seek eye care from primary care physicians than from ophthalmologists.[25] However, data from a study by Brechner et al. showed no difference between Whites and Blacks with diabetes in the proportion who received a dilated eye examination in the past year.[26] Non-Whites may underuse care services because they are less likely than Whites to have either the financial means or insurance coverage that is comprehensive enough to provide for recommended diabetes care.[27,28]

These findings are subject to several limitations. First, the data reported here came only from the 39 states that used the diabetes module. However, the characteristics of the persons with diabetes living in these states were similar to those of persons with diabetes in the other 11 states and the District of Columbia that did not use the diabetes module, except that there was a lower proportion of Blacks in the analysis sample (data not shown). Second, because the BRFSS is a telephone survey, results may not be representative of households without telephones or of population groups with low rates of telephone ownership. Such bias might be minimal, because reports have shown that only 6% of the US population cannot be reached by telephone[29]; however, persons of low socioeconomic status are less likely than more affluent people to own telephones and therefore are undersampled.

A third limitation is that recall bias is expected in any survey based on self-reported information. Nonetheless, several studies



Note. Adjusted for age, sex, health insurance, dilated eye examination, and visit to the doctor in the last year. HS = high school education.

FIGURE 2—Multivariable-adjusted prevalence of visual impairment among users and nonusers of insulin by race/ethnicity and level of education: Behavioral Risk Factor Surveillance System, 1995.

have shown the good reproducibility and validity of the BRFSS questions.[30–32] Moreover, the validity of self-reported diabetes has been shown to be excellent when the self-reports are compared with medical records, physical examinations, and physician reports.[33–36] In addition, 1 study that compared patients' recall with medical records showed that persons with diabetes recalled the use of insulin accurately.[37] Results of these studies therefore suggest an accurate recall of diabetes status and insulin use.

Another study, however, revealed that by using a telephone interview, the BRFSS questionnaire markedly underestimates the true prevalence of hypertension.[33] Shea and colleagues demonstrated the high reliability for the sociodemographic questions of the BRFSS in different ethnic groups,[32] but employment and income were the 2 variables that had a low reporting consistency.[38] The question on dilated-eye examination was used and validated in the Diabetic Eye Disease Follow-Up Study, which found high agreement between answers to the question and the medical record.[39]

National education programs have emphasized the need for dilated-eye examinations to prevent blindness from retinopathy and glaucoma.[5] It is estimated that eye care to prevent blindness among persons with diabetic retinopathy could yield annual net national savings exceeding $500 million.[5] Although most people with diabetes have a higher frequency of visual impairment and are at higher risk for mortality,[40,41] falls and hip fractures,[42] limitations in mobility and physical functioning,[43] and decreased quality of life[44] than are persons without diabetes, inadequate attention has been paid to the impact of lesser degrees of visual impairment. Several efficacious and cost-effective treatments now exist that can prevent or reduce the burden of disability and limitation to the quality of life.[45–49]

A high proportion of persons with diabetes could benefit from better refractive correction or cataract surgery. The Baltimore Eye Survey found that for 3 out of 4 persons in the general population with visual acuity below 20/40, uncorrected refractive error is to blame, and subgroups with the highest levels of impairment received the greatest absolute benefit from correction.[22] Thus, efforts aimed at increasing awareness of the importance of refractive correction may yield substantial improvement in visual functioning for persons with diabetes. Education programs should target all persons with diabetes and should be specifically designed to reach high-risk subgroups, such as persons with a low level of education and members of minority groups who do not use insulin.

The BRFSS survey also found that the level of reported impaired vision was not related to use of ambulatory medical or eye care services, which suggests that there is a missed opportunity to protect the vision of persons with diabetes and thereby improve their health status. Self-rated visual function may account for as much as 13% of overall general health status.[50] Health care providers should therefore be encouraged to assess visual functioning as well as central acuity.

According to the present study's estimate, more than 1.6 million adults with diabetes reported having some degree of impaired vision. Future research on the specific causes of visual impairment may help to estimate the avoidable public health burden associated with visual impairment among persons with diabetes. □

Contributors

J.B. Saadine and G.L.A. Beckles were responsible for the conception and design of the study, the analysis and interpretation of the data, and the writing of the paper. K.M.V. Narayan contributed to the analysis and interpretation of the data. M.M. Engelgau and R. Klein reviewed the paper and assisted in the interpretation of the data. R.E. Aubert contributed to the interpretation of the data and was one of the many who helped design the visual functioning questions in the BRFSS diabetes module. All authors approve the final version of the paper.

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